ROTARY ELECTRIC MACHINE HAVING LAMINATED ARMATURE CORE

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims benefit of priority of Japanese Patent Application No. 2003-129361 filed on May 7, 2003, the content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a rotary electric machine such as a starter motor that has a laminated armature core fixed to a rotatable center shaft.

2. Description of Related Art

An example of a rotary electric machine having a laminated armature core fixed to a rotatable center shaft is shown in JP-A-8-214481 or JP-A-2002-199626. The armature core disclosed therein is formed by laminating core sheets, each having a center hole, and by forcibly inserting a center shaft into the center holes of the laminated core sheets.

The following problem is involved in the conventional structure of the armature core. That is, a large amount of force is required to forcibly insert the center shaft into the center hole because the center hole is a continuous round hole. It is possible to reduce the inserting force by enlarging the diameter of the center hole (i.e., by reducing an amount of the diameter to be enlarged

by forcibly inserting the center shaft). However, if the diameter of the center hole is enlarged too much, the laminated core sheets would not be firmly connected to the center shaft. Alternatively, knurls may be formed on the center shaft to firmly connect the center shaft to the laminated core sheets. However in this case, it is necessary to precisely control the diameter of the center hole, resulting in an increase in the manufacturing costs.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above-mentioned problem, and an object of the present invention is to provide an improved rotary electric machine, in which laminated armature core sheets are firmly connected to a center shaft without increasing manufacturing costs.

The rotary electric machine is composed of a housing forming a magnetic field therein and an armature rotatably supported in the housing. The armature includes an armature core formed by laminating core sheets and a shaft connected to the armature core by forcibly inserting the shaft into a center hole of the armature core. Slots for disposing conductor segments therein are formed on the outer periphery of the armature core.

Each core sheet is stamped out from a steel plate, and a center hole and outer holes connected to the center hole are simultaneously formed. Core sheets forming one armature core are divided into three blocks. Core sheets in

each block are laminated so that the outer holes are aligned straight in the axial direction. The three blocks are laminated so that the angular positions of the outer holes around the axial direction are shifted by a predetermined angle block by block, thereby forming air passages through the armature core in the axial direction. The air passages are skewed relative to the axial direction. The predetermined sifting angle is preferably set to an angle corresponding to one slot pitch.

Since the contour of the center hole is not continuous but separated by the outer holes connected thereto, an amount of deformation of the center hole caused by forcibly inserting the shaft into the center hole can be made relatively large. Therefore, the shaft can be inserted by a relatively small amount of force and can be firmly connected to the laminated armature core. It is not necessary to form knurls or the like on the shaft, and therefore, there is no need to precisely control the diameter of the center hole. Thus, the armature can be manufactured at a low cost. Further, since the air passages are formed through the armature core, the rotary electric machine is effectively cooled. By skewing the air passages relative to the axial direction, cooling efficiency is further improved.

The core sheets may be laminated without dividing into blocks. The air passages may be made without making the skew relative to the axial direction. Each conductor segment disposed in the slot may be formed to include a coil end bent

from an in-slot portion at a right angle. The coil ends are circularly arranged on an axial end surface of the armature core, thereby forming a commutator surface. Brush powder generated by abrasion is effectively exhausted through the air passages formed through the armature core.

Other objects and features of the present invention will become more readily apparent from a better understanding of the preferred embodiment described below with reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view showing an armature core, viewed from an axial end of the armature core;

FIG. 2 is a side view (partially cross-sectioned) showing laminated armature core sheets;

FIG. 3 is a cross-sectional view showing a rotary electric machine according to the present invention;

FIG. 4 is a side view (partially cross-sectioned) showing the armature core with a center shaft; and

FIG. 5 is a cross-sectional view showing an armature according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described with reference to accompanying drawings. A rotary electric machine according to the present invention is used, for example, as a starter motor for cranking an

internal combustion engine. As shown in FIG. 3, the starter motor 1 is composed of: a housing constituted by a cylindrical yoke 2 having a front end wall 8 and a rear end frame 9; stator poles 3 (permanent magnets) fixed to the inner bore of the yoke 2; an armature 4 rotatably supported in the housing; brushes 5 for supplying electric current to the armature 4 from an on-board battery; and other associated components.

The armature 4 is composed of a shaft 6, an armature core 7 fixed to the shaft 6, conductor segments disposed in the armature core 7, and a commutator formed by coil ends of the conductor segments. The shaft 6 rotataby supported in the housing by a front bearing 10 fixed to the front end wall 8 and a rear bearing 11 fixed to the rear end frame 9. A sun gear 12 for constituting a planetary gear reduction mechanism (not shown) is formed at the front end of the shaft 6.

As shown in FIG. 2, the armature core 7 is composed of three core sheet blocks 14 consisting of respective core sheet blocks 14A, 14B and 14C. Each sheet block 14A-14C is formed by laminating core sheets 13 shown in FIG. 1. The core sheet 13 is stamped out from a thin steel plate. The core sheet 13 has a center hole 13a at its center, slots 13b on its outer periphery. The slots 13b are formed at an equal interval, which is referred to as a slot pitch. Outer holes 13c connected to (or opened to) the center hole 13a are also formed at an equal interval as shown in FIG. 1. Therefore, the center hole 13a does not have a continuous contour but a

contour intercepted by outer holes 13c which are connected to the center hole 13a.

A certain number of stamped core sheets 13 are laminated so that the outer holes 13c are aligned straight in the axial direction, thereby forming each core sheet block 14A-14C. The core sheet block 14B is laminated on the core sheet block 14A so that the outer holes 13c of the core sheet block 14B are sifted from those of the core sheet block 14A by a predetermined angle e.g., an angle corresponding to one slot pitch. The core sheet block 14C is laminated on the core sheet block 14B in the same manner so that the outer holes 13c of the core sheet block 14C are shifted from those of the core sheet block 14B by the same predetermined angle. The shaft 6 is forcibly inserted into the center holes 13a of the laminated core sheet blocks 14. In this manner, air passages 15 (shown in FIG. 4) are formed through the armature core 7 in its axial direction. The air passages 15, however, do not extend in parallel to the shaft 6 but are skewed because the outer holes of each core sheet block 14A-14C are shifted from one another by an predetermined angle, e.g., by one slot pitch. The shaft 6 which is forcibly inserted into the center hole 13 has a smooth surface, i.e., no knurl or the like is formed on the outer surface.

As shown in FIGS. 3 and 5, an inner conductor segment 16 and an outer conductor segment 17 are disposed in each slot 13b. The inner conductor segment 16 has an in-slot portion 16a disposed in the slot 13b and a pair of coil ends

16b which are bent at a right angle from the in-slot portion 16a and disposed on axial end surfaces of the armature core 7. Similarly, the outer conductor segment 17 has an in-slot portion 17a and a pair of coil ends 17b. The coil end 16b has a projected portion 16c extending in the axial direction. The projected portion 16c of the inner conductor segment 16 is electrically connected to a tip of the coil end 17b of the outer conductor segment 17. In this manner, an armature coil disposed in the slots 13b is formed.

As shown in FIG. 3, an insulating plate 18 having holes 18a corresponding to the air passages 15 is disposed between the axial end surface of the armature core 7 and the inner conductor 16. Both of the front end surface and the rear end surface of the armature core 7 are insulated from the inner conductors 16 in the same manner. Another insulating plate 19 is disposed between the inner conductor segment 16 and the outer conductor segment 17 at each axial end of the armature core 7.

The coil ends 17b of the outer conductor segment 17 are formed so that its thickness is gradually increased from the outside of the armature core 7 toward the inside thereof, as shown in FIGS. 3 and 5, thereby making a slant angle α shown in FIG. 3. The cross-sectional area of the coil end 17b is made uniform throughout its entire length by gradually narrowing its width from the outside toward the inside. The coil ends 17b form a commutator surface 17c by circularly

arranging the coil ends 17b on the rear end surface of the armature 7.

As shown in FIG. 3, brushes 5 made of, e.g., a copper material, contact the commutator surface 17c. The brushes 5 are biased toward the commutator surface 17c by brush springs 20. The brush 5 and the brush spring 20 are held in a brush holder 21 which is fixedly connected to the rear end frame 9. The tip surface of the brush 5 is slanted by the slant angle α to realize a smooth contact between the brush 5 and the commutator surface 17c.

The following advantages are obtained according to the present invention. Since the outer holes 13c connected to the center hole 13a are formed on the core sheet 13, the contour of the center hole 13a is not continuous but separated by the outer holes 13c. Therefore, when the center hole 13a is enlarged and deformed by forcibly inserting the shaft 6, some core sheet material escapes into the outer holes 13c. Accordingly, a force required for inserting the shaft 6 into the center hole 13a of the armature core 7 is reduced, compared with the conventional structure in which the center hole 13a is made continuous. The armature core 7 can be firmly connected to the shaft 6 with a relatively low inserting force. Further, it is not required to form knurls on the shaft 6 to firmly connect the armature core 7 to the shaft 6. Therefore, it is not necessary to form the center hole 13a with a high precision. Thus, the manufacturing costs can be reduced.

Since the air passages 15 are formed in the armature core 7 by the outer holes 13c, the armature 4 is effectively cooled by the air flowing through the air passages 15. Therefore, the rotary electric machine 1 can be operated at a high speed. Further, the air passages 15 are not parallel to the axial direction but they are skewed. By making the skew direction match the direction of airflow generated by rotation of the armature 4, air resistance in the air passages 15 can be reduced, and thereby cooling efficiency can be further improved.

Brush powder generated by abrasion between the brushes 5 and the commuator surface 17c can be carried out through the air passages 15 formed through the armature core 7. Accordingly, adhesion of the brush power to the commutator surface 17c is effectively avoided. Thus, the operating life of the brushes 5 is improved.

The present invention is not limited to the embodiment described above, but it may be variously modified. For example, three core sheet blocks 14A-14C may be laminated without shifting the positions of outer holes 13c. In this case, the air passages 15 are formed in parallel to the axial direction without making the skew relative to the axial direction. The core sheets 13 may be laminated without dividing into core sheet blocks. In this case, all the core sheets 13 may be laminated without shifting the angular positions of the outer holes 13c, forming the straight air passages 15 through the armature core 7. Alternatively, the

core sheets 13 may be laminated by shifting the angular positions of the outer holes 13c sheet by sheet, forming the skewed air passages 15.

In shifting the angular positions of the outer holes 13c, block by block or sheet by sheet, an amount of the shift is set to one slot pitch, or an integer number of times of the slot pitch. In this manner, the slots 13b formed on the outer surface of the armature core 7 extend straight in the axial direction. Therefore, the in-slot portions 16a, 17a of both conductor segments 16, 17 are easily disposed in the slots 13b.

Further, the core sheets 13 having the center hole 13a and the outer holes 13c may be laminated without aligning angular positions of the outer holes 13c. In this case, the air passages 15 are not formed, but the force inserting the shaft 6 into the center hole 13a can be reduced.

While the present invention has been shown and described with reference to the foregoing preferred embodiment, it will be apparent to those skilled in the art that changes in form and detail may be made therein without departing from the scope of the invention as defined in the appended claims.